Control of slow orbit motion in the Tevatron

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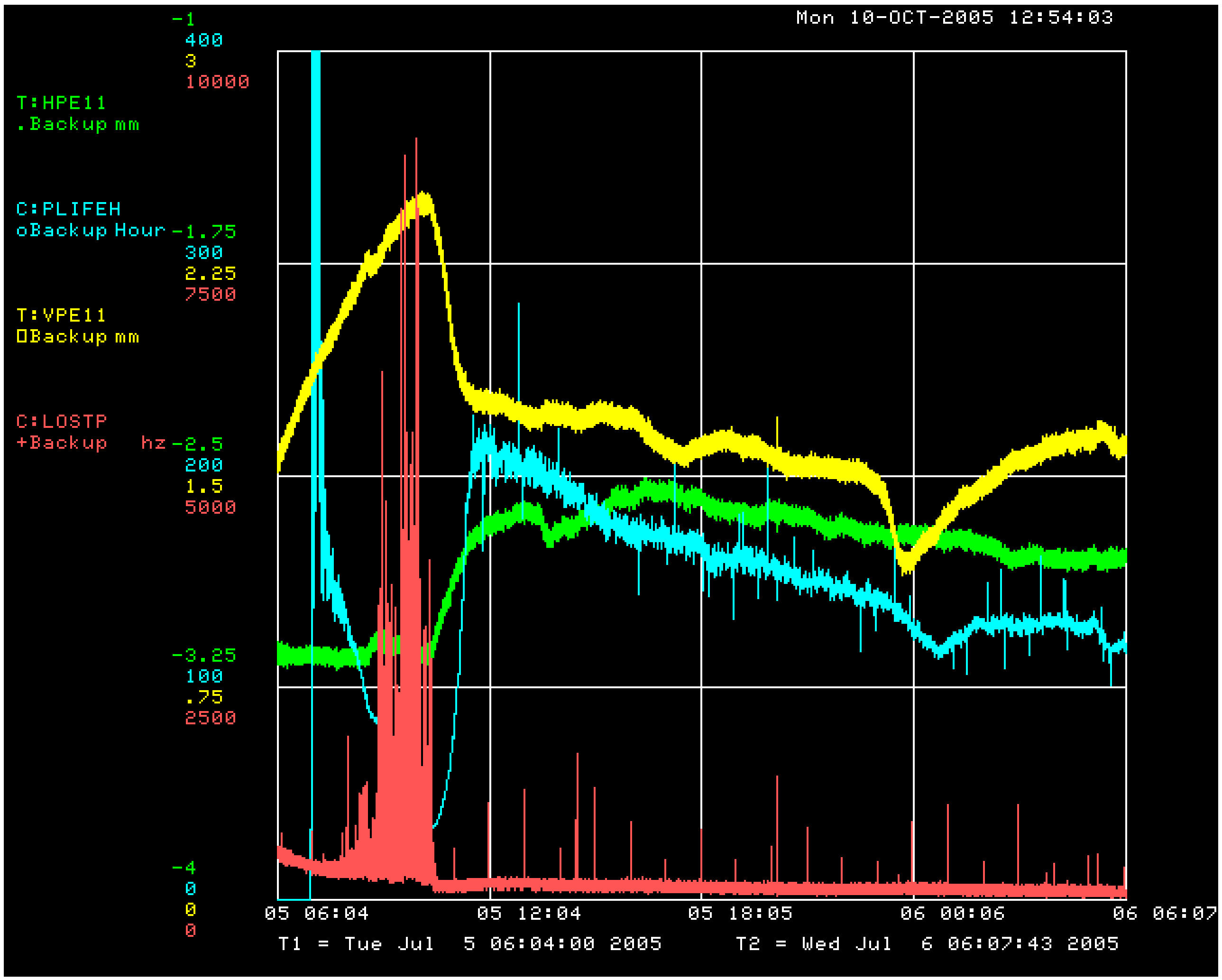
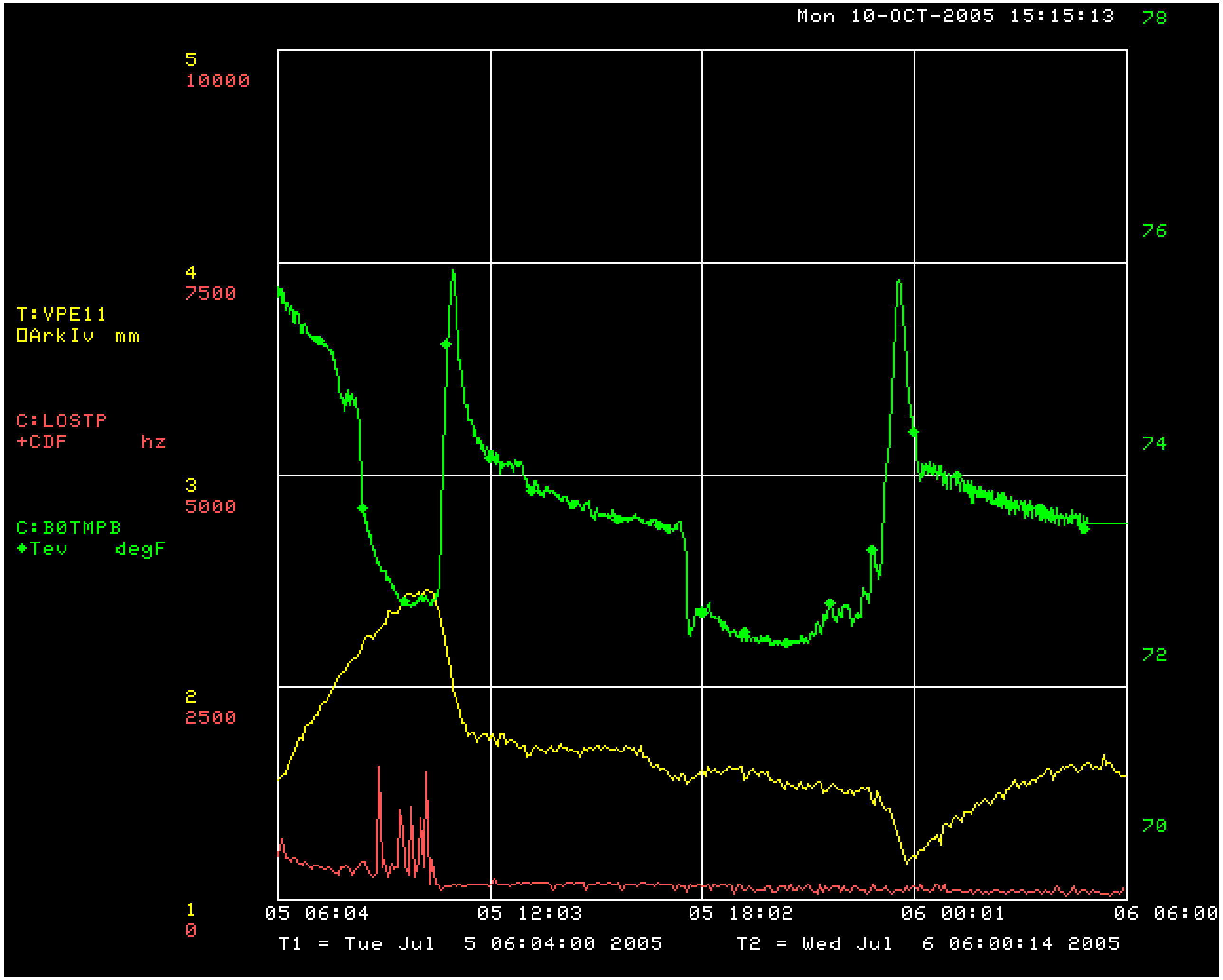
Slow orbit motion problem in the Tevatron

- Can lead to high losses at the experiments
- Lowers beam lifetime and leads to tune and chromatic drift.
- Causes of orbit motion:
  - Ground motion: tectonic motion, Tides, human activity
  - Ground motion differentials between Experiment halls and rest of ring.
  - Temperature, humidity, driven by HVAC cycles

- Changes at the low Beta quads are magnified by as much as 20 times. So a 20 micron change could cause a 0.4 mm change in orbit.
- Due to this motion it has been necessary to smooth about once every store. However we found that swings on the order of 1 mm can occur during less than 2 hours. This has motivated the development of an orbit stabilization program which can cycle every 30 secs.

Store 4250 example of slow orbit motion





Mon 10-OCT-2005 15:15:13
T:VPE11
DArkIv mm
C:LOSTP
+CDF hz
C:B0TMPB
+Tev degF
5
10000
4
7500
3
5000
2
2500
1
0
78
76
74
72
70
05 06:04
05 12:03
05 18:02
06 00:01
06 06:00
T1 = Tue Jul 5 06:04:00 2005
T2 = Wed Jul 6 06:00:14 2005

Using SVD to calculate location of Orbit Corrections.

- Using betas and phases of correctors and BPMS a Corrector to position response Matrix can be constructed:

$$R_{ij} = \frac{\sqrt{\beta_i \beta_{cj}}}{2\sin(\pi\nu)} \cos(|\psi_i - \psi_{cj}| - \pi\nu)$$

$$\Delta X = R \Delta \theta$$

- This matrix can be inverted using SVD to find the position to corrector matrix

$$\Delta \theta = R_{inv} \Delta X$$

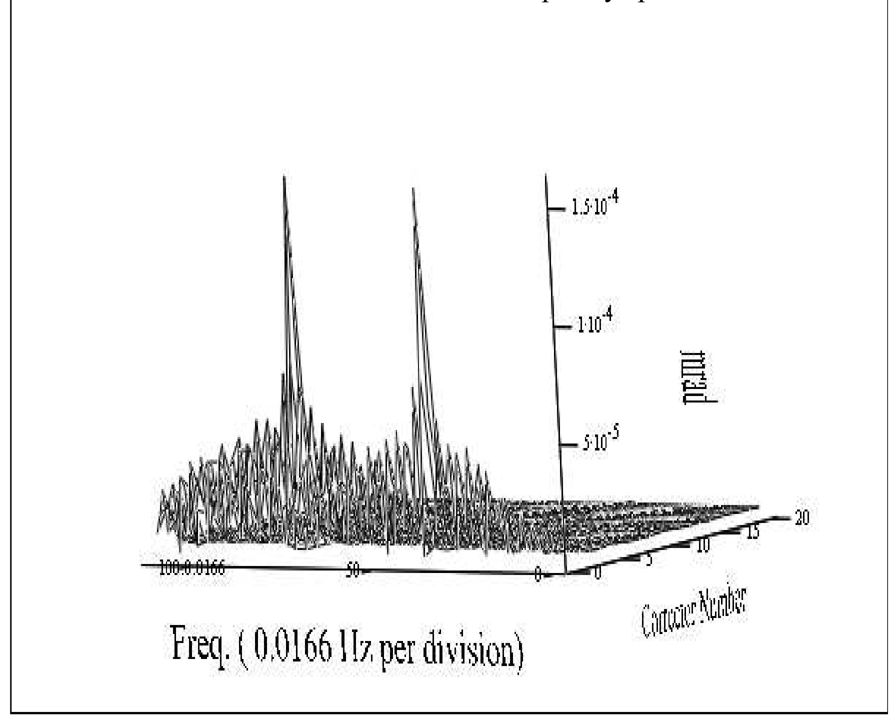
$$where \quad ,$$

$$R_{inv} = V W_{inv} U^T$$

Identifying Correctors necessary to Control motion

- Applying SVD correction algorithm every 30 secs we to the sampled orbit we could identify the most effective correctors necessary to control this motion.
- They occur at HA49 and HC49

Horizontal Correctors in frequency space



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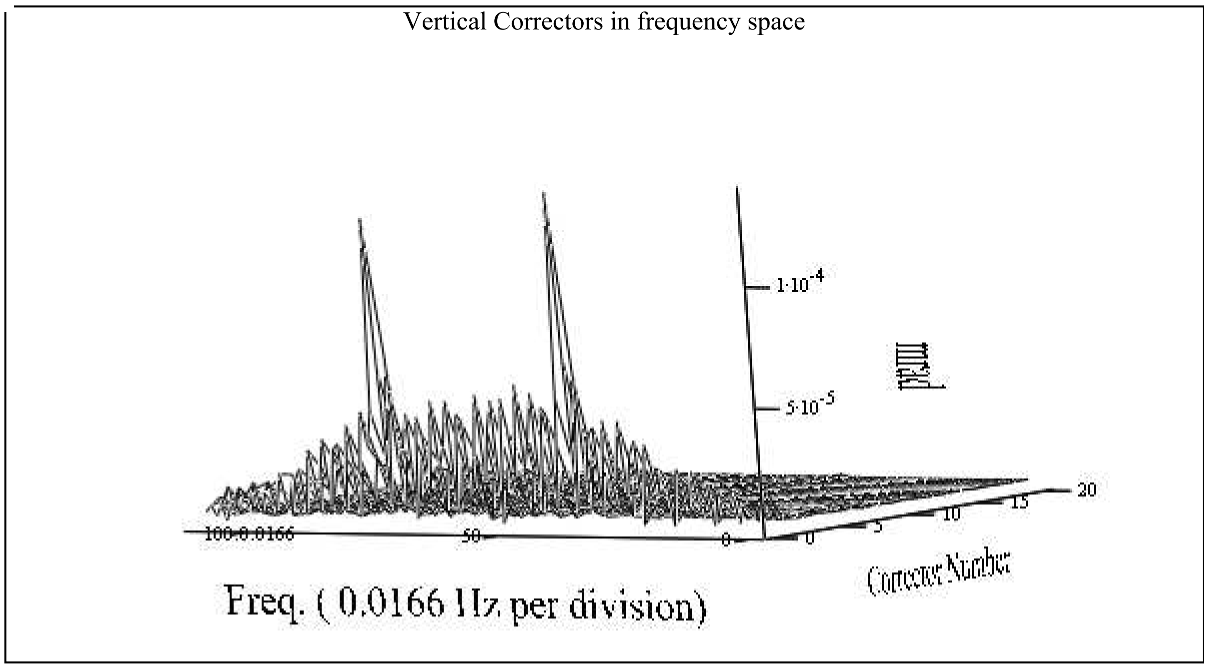
• For VerticalMost correction occurred at VB11 and VD11.



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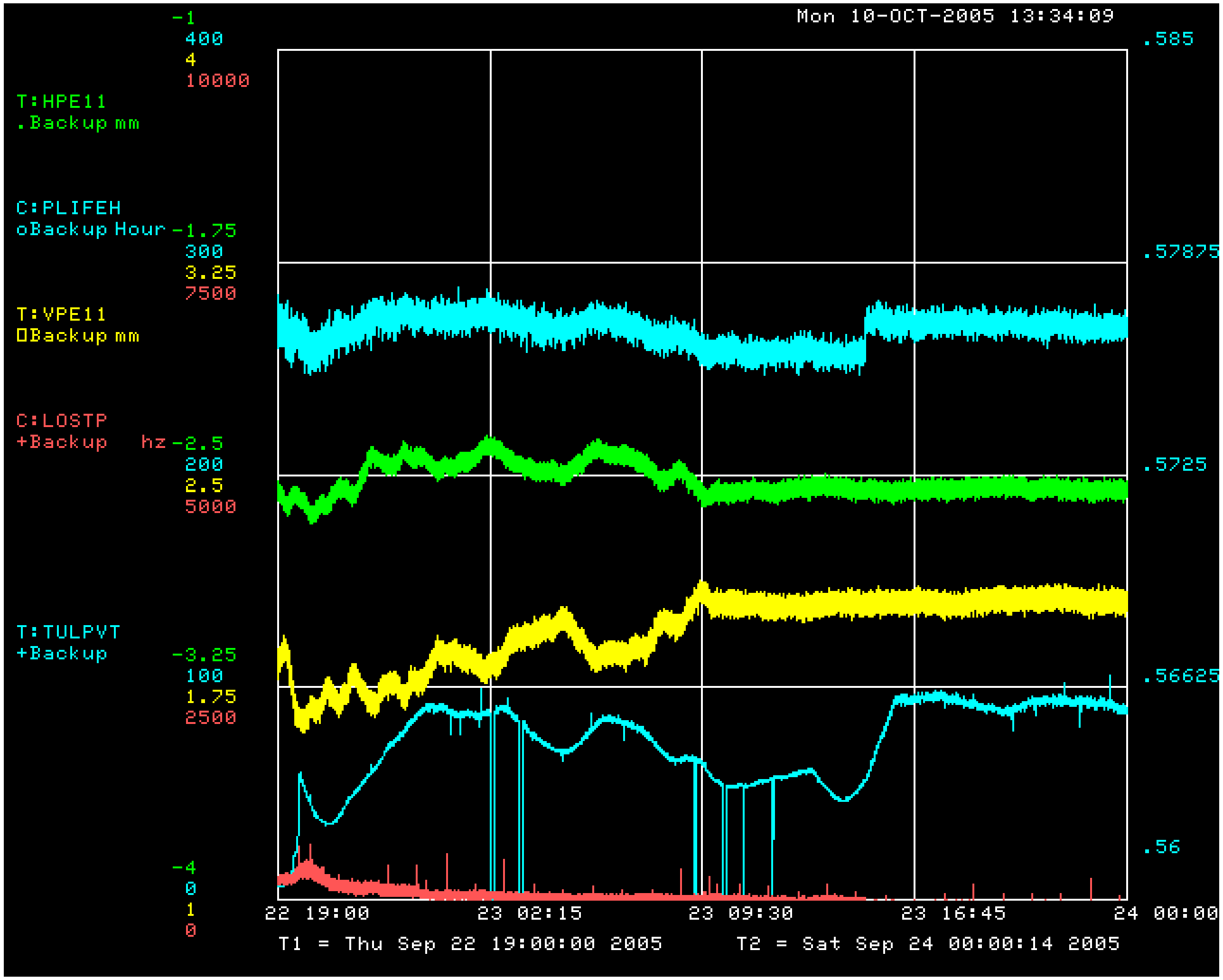
C55 Orbit stabilization program

- Turns on once HEP is reached.
- Sets up SVD matrix for horizontal and vertical correction based on optics.
- Samples initial orbit and then every 30 secs applies corrections to HA49, HC49 and VB11 and VD11 correctors to maintain existing orbit.
- Along the way does bpm and correction error checks. Limiting the maximum correction change applied and bpm change.
- Turns off at the end of HEP.
- Can be run as a slot 7 program. Controlled by state device V:TORBFB
- Status of program indicated on C:TORFBST

With orbit stabilization running half way through store.



Remaining orbit issues

- While we now have a system to correct orbit motion < 1 Hz. There remains a persistent horizontal orbit motion on the order of 17 Hz at 0.04 mm.
- Additionally there are occasional fast spikes in losses caused by sudden orbit motion. (earth quakes, human motion.)
- To control this motion out to 17 Hz we are in the process of building a fast orbit stabilization system using only a few BPMS which will transmit their positions over Ethernet > 50 Hz and drive correctors using either MDAT channels or CAMAC summing modules.